MINISTRY OF AGRICULTURE, EGYPT.

Technical and Scientific Service.
Bulletin No. 30. (Botanical Section.)

A BANANA DISEASE CAUSED BY A SPECIES OF HETERODERA.

By TEWFIK FAHMY, D.I.C.,
Mycologist, Ministry of Agriculture.

(Recommended for publication by the Publications Committee of the Ministry of Agriculture, which is not as a body responsible for the opinions expressed herein.)

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MINISTRY OF AGRICULTURE, EGYPT.

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A BANANA DISEASE CAUSED BY A SPECIES OF HETERODERA.

I.—Introduction.

Over twenty years ago, a banana disease was first observed at Alexandria ; it was said to have started in a few plantations and soon spread, causing a great deal of damage.

In 1901, Dr. Alex Preyer published a short article on this disease in the "Journal of the Khedivial Agricultural Society,"(1) attributing it to a parasitic nematode or eel-worm. During the following year Dr. Looss and Mr. Foaden, at the request of the Alexandria Municipality, visited an infected plantation at Gabbari, where the disease was causing great havoc. Later they published a preliminary report (2) on the nature of the disease, suggesting that parasitic worms, if they are not the sole cause of the disease, at least play by far the most important role in bringing it about. They suggested also that the worm was a Heterodera, probably in association with at least one other species of parasitic nematode.

Dr. Looss's and Mr. Foaden's investigation was of a preliminary nature. They studied the disease, gave a short description of the probable life history of the principal parasite, namely a Heterodera, which according to them does not belong to the species *radicicola*, but differs from it by the absence from its mouth cavity of a very fine sharp protrusive boring dart, the presence of which characterises the species *radicicola*.

In 1903 Mr. Victor Mosseri (3) published in the *Bulletin de l'Institut Egyptien* an important paper dealing with *Heterodera radicicola* and *Heterodera schachtii*, the former found parasitic on the roots of banana and many other plants, and the latter on beet-root. Mr. Mosseri included a brief description of the parasite on the same lines as those adopted by Dr. Atkinson in his paper (4) previously published in America.

Contrary to Dr. Looss and Mr. Foaden, he thought that the Heterodera concerned belongs to the Radicicola species. Nevertheless,

Mr. Mosseri was of opinion that the species mentioned by the above writers may be found in association with the true parasite, *H. radicicola*, but that it is of a secondary importance.

Mr. Mosseri then proceeded to give a list of 109 plants considered susceptible to the attack of *H. radicicola*, and suggested that, though sometimes each plant has its special Heterodera parasite, frequently one parasite is capable of passing from one plant to the other without great difficulty. Hence, if one considers, on the one hand, the diversity of the orders of plants susceptible to the attack of *H. radicicola*, and, on the other hand, the fact that certain plants considered resistant in one locality may become susceptible in another, one is led to think that the parasite spares no plant; that even in case of the absence of its most suitable host, it can satisfy itself with whatever plant is within its reach.

Since the researches of the above-mentioned workers, in spite of the great losses caused by this disease, it appears that no work of importance has been published on it in this country, or, as far as is known, elsewhere.

At the commencement of this investigation, Alexandria being the district where bananas are most grown commercially, it was decided to visit this district and to study the external symptom and any factors which might influence directly or indirectly the disease. Many plantations were examined, and though the severity of the attack varied, the external symptoms were all similar, showing that one disease only was the cause of the trouble.

Typically diseased trees were brought to this laboratory for further investigation, and portions of roots, stems, pseudostems and leaves were examined microscopically, some in the fresh state and others after embedding in wax and microtoming.

The Occurrence of the Disease.

Seventy plantations were visited during the autumn and winter of 1921–1922, twenty-eight in Upper Egypt, twenty-four in Lower Egypt, and eighteen in the Alexandria district; in fact, plantations in every province were examined. In each case a few plants which showed some signs of the disease were pulled out, and the adherent soil washed from the roots which were then examined. No plantation was found to be absolutely free from plants bearing galls at their roots.

Although the disease was present in all provinces south of Asyût, no external signs of the disease were observed, and it was not till

the plant was dug up that the disease was found to be present. In no case examined did it seem to be serious enough to render the plantation uneconomic. North of Asyût, the disease increased; in fact, in certain gardens it was so serious as to render the plantation worthless.

In Lower Egypt, with the exception of the Alexandria district, banana plantations, though numerous, are as a general rule inferior to those of Upper Egypt. The soil and climate are unsuitable, and under such unfavourable conditions the disease often gets the upper hand ; growth is slow and the roots destroyed by the parasite are not easily and quickly replaced.

The Alexandria district hes been for many years a favourite place for commercial banana-growing, and has in fact up to now been considered the best district in Egypt for this purpose. Nozha, Sidi Gaber, Victoria, Haggar el Nawatîa, Hadra, Toheen, El Maamûra, Abu Qîr, Gabbari, and many other places were visited.

In all these districts disease was present in varying degrees, but in spite of this the plantations seemed to be on the whole the best in Egypt from the point of view of fruit-production.

The soil in the Alexandria district is by no means uniform throughout, and no special soil feature, cultivation or treatment could be found to account for the good condition of the banana plantations there. The climate seems to be undoubtedly the most important factor. Alexandria, although situated in the north, has the advantage of a mild, humid climate. During the winter, also, the difference between the maximum day temperature and the minimum night temperature is not so great as to arrest entirely, or even to check seriously, the formation of the bunch. In fact, it is due to this salutary climate that growth and fruit-formation are rendered continuous, a very important matter for the successful economic production of bananas.

The Symptoms.

The diseased plant seems to struggle against some factor which prevents its growth, as if it were suffering from starvation. The plant is dwarfed, its leaves being small and upright and forming a miniature rosette. The crowded method of their growth causes the pseudostem to split open, while the plant remains as if paralysed till some injury or the increasing invasion of the parasite causes rot to set in. The plant then dies, often leaving suckers which may at first appear healthy but sooner or later become equally diseased.

On careful examination, the roots show the following characters: some are rotten, some bear galls or swellings, while others appear

healthy. All which are not rotten show numerous dark dots, which on closer examination prove to be where the rootlets once took their origin. Some of these rootlets still hang on the main roots, but almost all are in a decomposed condition.

In the face of such symptoms, one is led to understand the reason for the starved state of the plant. The food supplied is greatly reduced owing to the rotten condition of many of the roots ; while the presence of galls on some undoubtedly retards the flow of sap. Thus growth is checked, the plant starves, and the external symptoms mentioned above become apparent.

It has been mentioned that some of the roots of the diseased plant are knotted or bear galls ; on cutting open these galls the following is observed : embedded in a crowded manner, and sometimes scattered also in the apparently non-galled root tissue, are small round bodies. These can be seen with the naked eye ; some are dark brown, somewhat irregular in shape, others have a dark margin and a pale yellow central portion, while others are entirely opaque. There may be many of these bodies, up to fifty or even more in one gall. When examined microscopically, they are found to be sacks or bladders formed by the swollen female nematode, which becomes filled with hundreds of eggs at maturity.

The Cause of the Disease.

During the tour made in Upper and Lower Egypt to investigate the banana disease, it was constantly observed that the state of the plants was directly correlated with the number of their roots attacked.

The following different stages of the disease could be distinguished :—

(1) When not more than ten per cent of the total number of the roots contained cysts of *Heterodera* the plant appeared healthy and was considered as a good productive tree.

(2) When up to thirty per cent of the roots showed signs of the disease, the plant commenced to show weakness.

(3) When over thirty per cent of the roots were attacked, the disease was externally apparent, the plant being dwarfed and growth sluggish.

(4) When over fifty per cent of the roots were attacked, in this case many of them were in a rotten state, the leaves showed the rosette condition.

There is thus a very apparent connection between diseased condition of the roots and the state of the plant, indicating that the factor causing these galls and the subsequent rotting is responsible for the disease.

II.—The Parasite.

The eggs which are found within the matured female are opaque, thin-shelled, smooth, and elliptical in shape, measuring from 80 μ to 90 μ by 30 μ to 40 μ at their widest point. At an early stage the contents of the egg are granular, without any definite structure. In the latter stage the embryo is seen coiled within the shell. When the embryo is fully grown, the shell is burst open by the pressure exerted from within. If the eggs are placed in a moist chamber and incubated at 25° C., they hatch within three days.

The larva is transparent, pale white in colour, and in shape slender and cylindrical. The head is rounded, whilst the tail ends in a fine point. The mouth, which is anterior, leads to an unconvoluted alimentary canal. The suctorial œsophagus is a thick tube, its lining being continuous with the external layer of the body. At this stage in *H. radicicola*, a sharp spear-like appendage is found in the mouth cavity, but no trace of this was observed in the present parasite. The œsophagus opens into the intestine, which is a flattened tube. The rectum is short and opens anteriorly. The anus is a transverse slit. The worm measures when newly hatched 150 μ long by 14 μ at its broadest point. At this stage it is not active, but if placed under warm, moist conditions, as in a moist chamber at 25° C., it shows great activity after twenty-four hours incubation.

When a developed cyst or matured female is examined microscopically, the enclosed young are observed to be at different stages of development. Some are still in the egg stage, others just liberated are observed to be more or less coiled up, while others are still more developed.

Sometimes the larvæ were observed in the process of moulting soon after hatching. The exact number of moults are not known in this species, but in the case of *H. radicicola* they are, according to Atkinson (4), three in number.

If diseased roots which are free externally from any larvæ are placed under moist warm conditions, as in a petri-dish containing a little sterile water, or in moist sterile soil, and maintained from eight to fifteen days at a temperature of 25° C., the roots rot and the fluid surrounding these roots on microscopic examination is seen to contain many actively moving larvæ. If this culture is maintained for three to five weeks longer under the same conditions, the roots become a rotten mass, and the larvæ, finding no suitable food, die off. It is probable that under natural conditions the larva passes but a short time in the soil before it finds a suitable root which it

can penetrate to complete its growth, and in which it can finally encyst. This suggests that the larval stage is passed partly in the soil, and that it is generally through the rotting of the roots that the parasite is liberated.

On microscopic examination of sections of diseased roots, streaks of gum are observed, leading from the exterior to the encysted female. The presence of this gum which is the natural reaction of the injured cells, suggests that it is caused by the penetration of the worm.

As mentioned above, the worm thus apparently penetrates into the root after passing part of its larval existence free in the soil.

This species of *Hetorodera* is definitely bisexual, but the act of fertilization was not observed nor is it known exactly where it occurs. The next stage observed was where the female was beginning to swell up. At this stage it is lemon-shaped, the head acquires a twisted appearance and is less swollen than the body.

At an early stage its contents are granular, consisting of many hundreds of opaque bodies, which later develop into the eggs, so that at maturity it is nothing but a sack of eggs.

The outside layer, originally the skin of the mother-worm, becomes dark in colour, and finally rots, liberating the eggs which are contained within, many of which have by that time hatched. The root in turn rots away, and worms and eggs are left free in the soil. Further infection proceeds by the worm making its way to a root which it penetrates, there finding food and protection to complete its life history. In this way the parasite soon invades the unattacked portions of the root-system, till it finally causes its complete destruction.

The Source of Infection.

Suckers bought for planting are rarely free from *Heterodera* cysts on their roots. Thus no sucker plantation examined, either at Belbeis or Ismailia, the two main centres for the sale of suckers, was found to be absolutely free from the parasite. The attacks, it is true, are only slight, but nevertheless, when these plants are sold for transplantation, the infection is brought with them. The parasite soon multiplies and in a short time, under favourable conditions, increases and produces the injury described above. Besides this, the roots of the host plants are more or less intermingled, and the parasite finds no difficulty in spreading from one plant to another. It is also probable that this *Heterodera* species attacks other plants growing in the same field, either as weeds or minor crops, and thus the parasite travels from one plant to another, or even from one field to another field, till it finally spreads over a large area.

It is possible that the infection originally started in only one centre and spread from one locality to another through the sale of infected suckers.

To show that infection is possible, two sets of experiments were carried out :—

(1) Healthy banana plants were planted in soil obtained from round the roots of diseased plants.

(2) Healthy plants were planted next to banana trees showing definite signs of the disease, such as galls on roots and rosette formation of the leaves.

In (1) 30 per cent became diseased and showed the characteristic external symptoms of rosetting after a period of eight months.

In (2) 40 per cent showed the disease to the same extent as (1) and after the same lapse of time.

On examining the roots of (1) and (2), many galls and cysts of *Heterodera* were observed, while the control showed no external signs of the disease.

As for the susceptibility of the different varieties to the disease, all varieties, namely the Hindi (*Musa Cavendishii*), the Baladi (*M. Sapientum*), and the Americani (*M. Sapientum* var. *paradisica*) are susceptible to the disease, though the external signs are more apparent in the Hindi than in the other varieties owing to its dwarf character.

The Connection between Soil Organic Matter and the Disease.

Suitable moisture and temperature are necessary conditions for the development of the parasite. These conditions are determined by the amount of organic matter in the soil. Thus organic matter assists the growth of the larva ; it also facilitates its movements and affords protection against any substance injurious to it which may be applied as a remedy.

When organic matter, such as horse dung, which by many planters is considered the best manure for banana trees, is added to the soil, its content of organic matter is increased and the conditions are rendered more favourable for the larval stage of the parasite.

The question therefore arises whether it is possible to replace the organic manure, generally applied to banana trees, by some inorganic manure which will equally satisfy the requirements of the plants without furnishing to the parasite the favourable conditions mentioned. Considered from the point of view of plant-food only, it is theoretically and practically possible to supply to the plant in an inorganic form the same chemical constituents as are present in horse dung.

Horse dung, however, besides supplying plant-food, creates certain favourable conditions, the most important of these being the increase of the water holding capacity of the soil and the giving up of this stored water as the plant requires it. The question therefore arises whether it is possible to induce these conditions without the presence of organic manure. Can one rely on the organic matter present in the soil without further increasing it and thus avoid furnishing the parasites with favourable conditions for its development?

Relationship between the Disease and the Plant-Food available.

The amount of food absorbed by the plant depends on two factors :—

(1) The plant-food available in the soil.

(2) The capacity of the roots to absorb it.

In the case of diseased banana trees, the rotten and galled conditions of many of the roots and the absence of the majority of the rootlets hinder normal root-absorption. If, however, only a part of the root-system is destroyed or injured, leaving the other part capable of functioning, the plant may be able to make good the loss, if the food-supply is sufficient. The food-supply must be ample and in an available form, so that no time is lost and growth may progress before the increase of the parasite.

This question as well as the former lead us to consider the relation between the disease, the manurial treatment, and the cultivation.

It has constantly been observed that neglected plants suffer much from eel-worm attack. In the case of old plantations where the disease is present, it is quite easy to understand that the nematode parasite population increases with the age of the plants, in many cases becoming so numerous that the plants cannot withstand the repeated attacks to which they are subjected. In such cases it is useless to attempt any treatment since the root-system is in such a rotten state that even if heavy dressings of complete chemical manures are applied, the benefit derived from these is slight. If, however, only a part of the root-system is destroyed, the plants do respond to manures, especially nitrogenous ones, and many produce suckers which are to all appearances healthy. This treatment does not seem to hinder the growth of the parasite, the plants have only been stimulated and vegetative growth induced, and during the following season the plants may again show definite signs of the disease.

To study this question, certain manurial experiments were undertaken.

The plant was observed to respond to generous applications of nitrogenous manures. It was found that nitrogenous manures are

of special benefit when applied to suckers which have just been planted out, for the plants make vigorous vegetative growth and are able to establish themselves before the winter sets in and growth comes to a standstill.

Connected with the manurial treatment there is the very important question of thinning the suckers to the proper number, so that the plant-food available may not be divided among too many plants to give any appreciable benefit.

III.—Methods of Control.

Having studied the parasite, the damage it does, and its host-plant and soil relationship, the most important remaining consideration is the methods of control.

The desirability of keeping the plants in a strong vigorous condition of growth by the application of artificial manures and by strict attention to hygiene has already been dealt with.

There remain the following possibilities for consideration :—

(1) The use of plants resistant to the disease.

(2) The use of a toxic substance to kill the parasite.

(3) Soil sterilization.

Up to the present, no indication has been obtained of any specially immune strains of banana.

The second alternative presents great difficulties owing to the greater part of the life-history of the parasite being spent within the tissues of the host.

According to Dr. Neal (5), carbon-bisulphide, arsenic, and other toxic compounds when injected into the soil in sufficient quantity and strength to destroy the nematode parasite, act equally unfavourably on the host.

The third alternative, that of soil sterilization, would appear to be feasible, but it should be very clearly recognized from the start that soil sterilization is useless unless effective means are taken to prevent the reintroduction of the parasite during replanting and during the subsequent cultivation and irrigation of the plants.

Considerable further study is necessary before it will be possible to make a pronouncement as to the usefulness of adopting control measures on these lines. The difficulties are great, but the high returns obtainable from banana plantations grown under the best conditions lend colour to the hope that something practicable may be devised.

It is proposed to carry out an extensive series of experiments along these lines and to publish the results of these experiments at a later date.

References.

(1) Dr. Alex Preyer. On a New Banana Disease in Egypt. "Journal of the Khedivial Agricultural Society and the School of Agriculture," Vol. III, No. 5, 1901, p. 242.

(2) Dr. Looss and Foaden. Preliminary Report on the Nature of the Banana Disease prevalent at Alexandria. "Journal of the Khedivial Agricultural Society and the School of Agriculture," Vol. IV, No. 1, 1902, p. 9.

(3) Victor Mosseri. Sur une Maladie Vermiculaire des Plantes observée récemment en Egypte. "Bulletin de l'Institut Egyptien," Quatrième Série, No. 4, 12 janvier 1903, Fascicule No. 1.

(4) Geo. F. Atkinson. Nematode Root Galls. "Report Agricultural Experimental Station Auburn (Alabama)," Bull. 9, 1889.

(5) Dr. Neal.—The Root Knot Disease of Peaches, Oranges, and other Plants in Florida. "U.S. Department of Agric., Div. Entomology," Bull. 20, 1889.

LIST OF ILLUSTRATIONS.

FIG. 1.

Fig. 2.

Fig. 3.

FIG. 4.

FIG. 5.

MAMOUN ABDEL SALAM
Delt et Pinxt

Natural Size

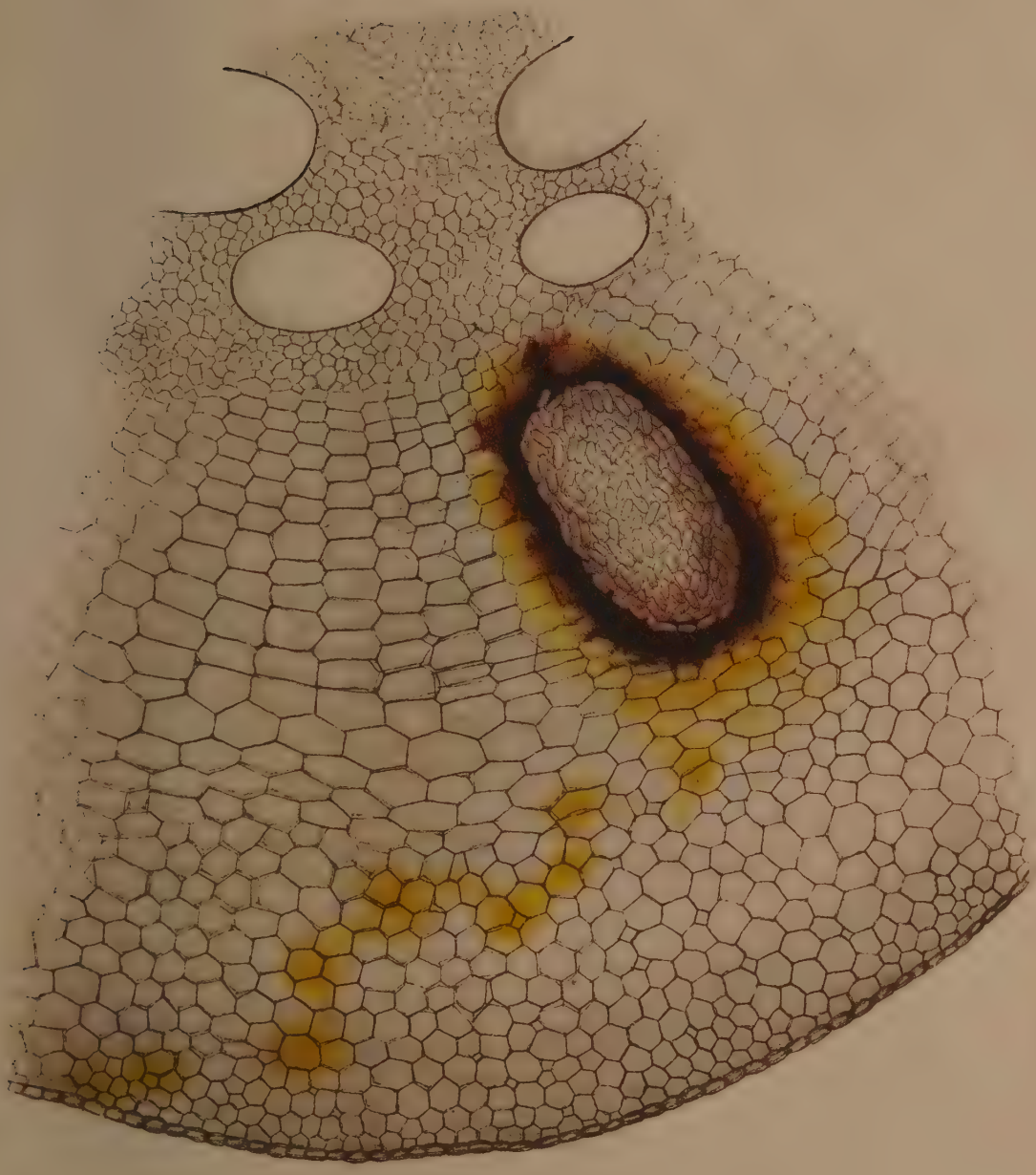

FIG. 6.

MAMOUN ABDEL SALAM
Delt et Pinxt.

130×

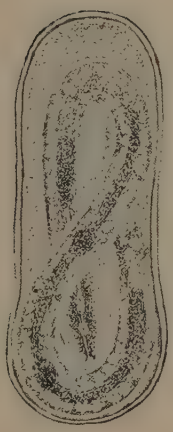

Fig. 8 شكل ٨

Fig. 7 شكل ٧

Mamoun Abdel Salam
Del et Pinxt

480 x
٤٨٠ x

Fig. 9 شكل ٩

Mamoun Abdel Salam
Del et Pinxt

630 x
٦٣٠ x

Fig. 10 شكل ١٠

Mamoun Abdel Salam
Del et Pinxt

480 x
٤٨٠ x

Fig. 12 شكل ١٢

Fig. 11 شكل ١١

Mamoun Abdel Salam
Del et Pinxt

40x
٤٠x

MINISTRY OF AGRICULTURE, EGYPT.

List of Publications in English issued by the Ministry.*

The following publications may be obtained, either directly, or through any bookseller, from the Government Publications Office, Ministry of Finance Dawawîn P.O.), Cairo.

Agricultural Journal of Egypt.

First Series.

Vol. I, 1911. Parts I and II, P.T. 2† each part.
.. II, 1912. Part I P.T. 2; Part II, P.T. 3.
„ III, 1913. Parts I and II, P.T. 3 each part.
„ IV, 1914. Parts I and II, P.T. 3 each part.
„ V, 1915. Parts I and II, P.T. 5 each part.
Vols. VI to X, 1916–1920. P.T. 5 each volume.

In 1923 a new series was started monthly in Arabic only. An English edition is published once a year containing articles selected from the year's Arabic issues.

New Annual Series.

Vol. I, 1923 (in the press).

Egyptian Agricultural Products (By Gerald C. Dudgeon).

No.
1 A. The Great Millet (*Durra Baladi* or *Durra Rafi'a*) in Egypt. P.T. 3.
2 A. The Ground Nut or Earth Pea (*Fûl Sudani*) in Egypt. P.T. 2.
3 A. Gossypium Spp., Cotton (*Qotn* in Egypt). History, Development, and Botanical Relationship of Egyptian Cottons, with tables showing Areas, Yields, Prices, and Distribution of the Varieties. P.T. 5.

Technical and Scientific Bulletins.

No.
1. Report on the First two Years' Working of the Plant Protection Law (Law No. 5 of 1913), by G. Storey. (English or French.) 1916. P.T. 2.
2. The Nature of the Damage done by the Pink Boll Worm (*Gelechia gossypiella* Saund.), by Lewis Gough. (English or French.) 1916. P.T. 1.
3. Note on the Alkaloids of some Egyptian Solanaceæ, by Frank Hughes. (English or French.) 1916. P.T. 1.
4. The Life History of *Gelechia gossypiella* from the Time of the Cotton Harvest to the Time of Cotton Sowing, by Lewis Gough. 1916. P.T. 1.
5. List of Egyptian Insects in the Collection of the Ministry of Agriculture, by G. Storey. 1916. P.T. 10.

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* Revised to March 1924.

† P.T. 1 = 5 cents = 2½*d.* approximately.

TECHNICAL AND SCIENTIFIC BULLETINS (*continued*).

No.

6. Note on a Machine to kill *Gelechia* Larvæ by Hot Air, and the Effects of Heat on *Gelechia* Larvæ and Cotton Seed, by Lewis Gough. 1916. P.T. 2.
7. Work in Connection with Egyptian Wheat, by G. C. Dudgeon and B. G. C. Bolland. 1916. P.T. 1.
8. Work conducted at the Experimental Farm at Gîza in connection with Great Millet and *Bersîm*, by B. G. C. Bolland. 1916. P.T. 1.
9. Work in connection with Egyptian Maize, by G. C. Dudgeon and B. G. C. Bolland. 1916. P.T. 1.
10. Some Tests of Flour made from Egyptian Wheat, by Frank Hughes. 1916. P.T. 1.
11. Simon's Hot Air Machine for the Treatment of Cotton Seed against Pink Boll Worm, by G. Storey. 1921. P.T. 1.
12. Experiment with Flax growing at the Government Farm at Gemmeiza, by G. C. Dudgeon. 1917. P.T. 2.
13. The Rate of Increase of the Pink Boll Worm in 1916, by Lewis Gough. 1917. P.T. 2.
14. Machines for the Treatment of Cotton Seed against Pink Boll Worm (*Gelechia gossypiella* Saund.), by G. Storey. 1921. P.T. 2.
15. Rusts and Smuts of Wheat, Barley, and Oats, by H. R. Briton-Jones. 1920. P.T. 2.
16. The Present Situation with regard to the Control of the Pink Boll Worm in Egypt, by G. Storey. 1921. P.T. 2.
17. The Hibiscus Mealy Bug, by W. J. Hall. 1921. P.T. 3.
18. The Smuts of Millet, by H. R. Briton-Jones. 1922. P.T. 3.
19. A Wound Parasite of Cotton Bolls, by H. R. Briton-Jones. 1923. P.T. 3.
20. The Fixation of Atmospheric Nitrogen, by Frank Hughes. 1922. P.T. 3.
21. Report on a Soil Survey of Zone No. 1 (Gharbîya), 1921, by Frank Hughes. 1922. P.T. 5.
22. Observations on the Coccidæ of Egypt, by W. J. Hall. 1922. P.T. 5.
23. (*Stopped.*) Subsequently published by the Société Entomologique d'Egypte, 1922, under the title: A Monograph of Egyptian Diptera (Part I, fam. Syrphidæ), by H. C. Efflatoun.
24. On the Dispersion of the Pink Boll Worm in Egypt, by Lewis Gough. 1922. P.T. 5.
25. The Basis of Egyptian Agriculture and its Relation to the Decline in the Average Yield per Feddân of Cotton, by E. McKenzie-Taylor and A. Chamley Burns. 1922. P.T. 5.
26. The Outbreak of Pseudococcus sacchari on the Sugar Cane of Egypt, by W. J. Hall. 1922. P.T. 3.
27. Statistics of Pink Boll Worm Occurrence from 1916–1921, by the Entomological Section. 1923.
28. A New Type of Light Trap for Insects, by C. B. Williams. 1923. P.T. 3.
29. A Short Bio-Climatic Study in the Egyptian Desert, by C. B. Williams. 1923. P.T. 5.
30. On Banana Disease caused by a Species of "Heterodera," by Tewfik Eff. Fahmy. (In the Press.)
31. Soil Temperatures during the *Sharâqi* Period and their Agricultural Significance, by E. McKenzie-Taylor and A. Chamley Burns.

TECHNICAL AND SCIENTIFIC BULLETINS (*continued*).

No.

32. The Cotton Plant in Relation to Temperature and Rainfall, by C. B. Williams. 1923. P.T. 2.
33. Preliminary Notes on Two Minor Pests of the Egyptian Cotton Crop (*Creontiades pallidus*, Ramb., and *Nezara viridula*, L.), by T. W. Kirkpatrick, 1923. P.T. 3.
34. Preliminary Note on the Soil Temperature in *Sharâqi* Land, by E. McKenzie-Taylor and A. Chamley Burns.
35. The Egyptian Cotton Seed Bug (*Oxycarenus hyalinipennis*, Costa). Its Bionomics, Damage, and Suggestions for Remedial Measures, by T. W. Kirkpatrick.
36. Further Observations on the Coccidæ of Egypt, by W. J. Hall.
37. Bioclimatic Observations in the Egyptian Desert in March 1923, by C. B. Williams.
38. A Multiple Temperature Incubator, by Messrs. C. B. Williams and T. W. Kirkpatrick. (In the Press.)
39. A Preliminary Note on the Loss by Boll Worms, by Ibrahim Eff. Bishara.
40. A Comparison of sand and soil temperatures in Egypt, by Messrs. E. McKenzie-Taylor and C. B. Williams.
41. Some New and Interesting Orthoptera in the Collection of the Ministry of Agriculture, Cairo, by B. P. Uvarov.
42. Experiments to determine the Susceptibility of Weaned Calves to Cattle Plague, the Calves being doubly inoculated while suckling with Virulent Cattle Plague Blood and Serum, by Mohamed Askar Bey.
43. Date Palm in Egypt, by T. W. Brown.
44. The Propagation and Cultivation of Citrus Trees in Egypt, by T. W. Brown.
45. The Insect Pests of Citrus Trees in Egypt, by W. J. Hall.
46. Four New Species of Coccidæ from Egypt, by W. J. Hall. (In the Press.)
47. Cotton Growing in relation to Climate in Egypt and the Sudan, by C. B. Williams. (In the Press.)
48. The Effect of Heat Treatment of Cotton Seed on its Germination and the Subsequent Growth and Development of the Plants, by J. Templeton. (In the Press.)
49. Mycological Work in Egypt, by Briton-Jones. (In the Press.)
50. Third Bioclimatic Study in the Egyptian Desert, C. B. by Williams. (In the Press.)
51. Statistical Note on the Cotton Variety tests at Sakha, 1916-1920, by T. Trought. (In the Press.)

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